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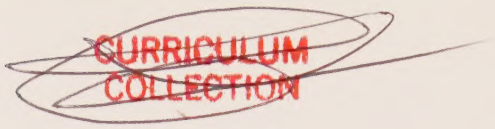

DUE DATE

FEB 21 1995			
	201-6503		Printed in USA

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Teacher's Guide for MATCH AND MEASURE

McGraw-Hill Book Company
8171 Redwood Highway
Novato, Calif. 94947

SCIENCE
Grades K-8

ESS: ELEMENTARY SCIENCE STUDY SERIES
Teacher's Guides

Book Label 7

WEBSTER DIVISION, McGRAW-HILL BOOK COMPANY
New York • St. Louis • San Francisco • Dallas • London • Sydney • Toronto

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Teacher's Guide for Match and Measure
Class Kit for Match and Measure

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Drops, Streams, and Containers
Geo Blocks
Growing Seeds
Light and Shadows
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ISBN 07-017721-X

Preface

The Elementary Science Study is one of many curriculum development programs in the fields of science, social studies, and mathematics under preparation at Education Development Center, Inc. EDC (a private nonprofit organization, incorporating the Institute for Educational Innovation and Educational Services Incorporated) began in 1958 to develop new ideas and methods for improving the content and process of education.

ESS has been supported primarily by grants from the National Science Foundation. Development of materials for teaching science from kindergarten through eighth grade started on a small scale in 1960. The work of the project has since involved more than a hundred educators in the conception and design of its units of study. Among the staff have been scientists, engineers, mathematicians, and teachers experienced in working with students of all ages, from kindergarten through college.

Equipment, films, and printed materials are produced with the help of staff specialists, as well as of the film and photography studios, the design laboratory, and the production shops of EDC. At every stage of development, ideas and materials are taken into actual classrooms, where children help shape the form and content of each unit before it is released to schools everywhere.

Acknowledgments

Elizabeth Barnett and I collaborated in developmental teaching to identify activities and materials which could help children learn about measurement. She wrote the Trial Teaching Edition of the *Guide*.

The children with whom we worked taught us that you can't *teach* measuring and showed us many common-sense ways to measure. We thank them and their teachers.

I wish to thank all the teachers who trial taught MATCH AND MEASURE, especially Janice Cooley, Lucille Daniels, Jean Field, Ann Gingerelli, Shirley Holloway, Reba Ann Lee, Vivian Lightfoot, Lisa Neustadt, Kathleen Raoul, Maia Scherrer, Phoebe Stern, Margery Thurber, and Caroline Lynn Wells. Their contributions are reflected in the present edition.

Norma Arnow helped develop the activities by teaching and observing trial classes. Many staff members were helpful. In particular, Norma Arnow, George Cope, Rose Lea Crowley, Mary S. Gillmor, Jay Hauben, Emily Romney, and Virginia Strong added useful suggestions to improve the manuscript. Photographs were taken by George Cope, Joan Hamblin, Victor Stokes, Allan Leitman, and myself. I also thank Adeline Naiman, who edited the manuscript, and Nancy Weston, who designed the book.

Edith H. E. Churchill

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Introduction

Long

Tall

Big

Small

Young children use these terms every day in conversation and play.

"I'm going to make a *long* garage for my trucks."
"I can build a tower *taller* than myself."
"David is *small*, so he'll play my little brother."

Children make comparisons and note similarities and differences long before they are ready to consider such questions as: How long . . .? How tall . . .? How much bigger . . .? How much smaller . . .?

Like everyone else, children use size words to describe things as they perceive them. A child, even more than an adult, sees the size of one thing in relation to the size of something else. What he classifies as "big" in one instance, he may call "small" in another. A piece of cake served to him is "tiny" when all the other pieces are larger. It is "huge" when all the other pieces are smaller.

That a child uses size words does not, however, mean that he understands what size is. For an adult, an object has an exact, consistent, measurable size. For a young child, the size of objects really is changeable. His notion of the size of something depends on how it looks to him at that moment. Even looking at it from a different angle may make it "be" more or less. Water poured from a drinking glass into a tall, thin tube may immediately become "more water," since the level of the liquid is higher in the tube than it was in the glass. A row of blocks flat on the floor may look shorter than the same row standing up as a tower. A ball of clay may lose or gain weight when it is broken into little pieces.

Likewise, a child uses number words in a descriptive, rather than a precise, way. When he sees a full box of dominoes, he may say that there are "a hundred," when actually there are many less. What he means is: There are a lot. Numbers used to describe quantity have little or no value to a child at this stage in his development. He may count out ten dominoes in a pile and say that there are ten, but when the same dominoes are spread out, he may think that there are more because they appear to take up more space.

Similarly, the standard units of measurement used by adults make little sense to most children. What is an inch, a quart, a pound, if the quantity or size changes as the substance changes position or shape? What do the numbers attached to inches, quarts, and pounds really stand for? How does 5 feet differ from 5 inches when both are 5?

By matching and comparing, thinking about his results, and generalizing from many experiences, a young child gradually comes to accept the idea that number, length, and quantity stay the same even when the appearance of objects changes. He finally

realizes that ten dominoes are ten no matter how he places them, and that a piece of string stays the same length whether he arranges it in a circle or in a straight line. He knows for sure that one cup of water remains one cup, regardless of the shape of its container. As he arranges and rearranges his dominoes and pours liquids from one container to another in different situations, he develops his ability to pay attention to several kinds of measurement at once — height *and* width, number *and* spatial arrangement.

The same experiences which enable a child to accept the fact that quantity is constant are necessary prerequisites of his grasp of the "how" and "why" of measuring. He begins by expressing the size of one object in terms of the size of another, goes on to establish standard units of his own, and gradually learns to handle conventional measuring tools with understanding. Conventional measuring devices lose much of their mystery if a child uses them alongside other tools of his own invention. Lacking this sequence of experiences, children frequently assume that conventional units of measurement are somehow *essential* to measurement. For some children, it seems as if length exists only when they have inches with which to measure it or that an object too large for the available scales will weigh "nothing."

Perhaps the most urgent message in this *Guide* is that measuring should not — really *cannot* — be "taught," either through problems in arithmetic or through a series of planned lessons. Learning to measure is a gradual process. Until a child has had a chance to establish in concrete, comparative terms what a foot and a yard are, "3 feet plus 2 feet" is meaningless to him.

People measure to obtain information for some purpose or to satisfy curiosity. They seldom measure simply for the sake of measuring. Measuring in the classroom will be most effective and interesting if it grows out of situations in which children are actively involved. Sewing, cooking, carpentry, and caring for animals are examples of activities that capture children's interest and provide opportunities for measuring. To make use of these opportunities, children need encouragement to pursue questions that interest them, access to a variety of measuring tools, and the freedom and time to use these tools as they see fit.

This *Guide* is a response to the expressed need of primary teachers for suggestions of ways to incorporate measuring into the life of their students. The materials and activities illustrate different methods children have found to compare and describe lengths, surface areas, and volumes. The tools and materials are some which have served to make possible a variety of measuring experiences.

The age level at which different activities will be appropriate cannot be specified exactly. There is tremendous variation among children of the same chronological age, both in their general maturity and in their previous experience. Although the activities were developed in kindergarten through

grade three, children up to grade six have profited from and enjoyed some of them. Fortunately, the children themselves solve the problem of what is appropriate to their needs if they are allowed to select from a variety of possible approaches.

Once you have created the opportunity for children to engage in activities in which the need to compare and measure will spring naturally out of concrete situations, a helpful suggestion can carry a child on to the next step. Watching a child as he works, and listening to his comments and questions, will provide the best clues to how he is looking at a problem. The teacher's role here is important. Your aim should be to keep sufficiently in touch with what children are doing so that when they have had full opportunity to try out their own ideas, you can intervene to add a new dimension to an activity and keep interest alive.

The pictures in the *Guide* suggest ideas even to children who are too young to read.

Materials

Supplied in Kit

- 1 yardstick
- 100 tongue depressors
- 2 boxes plastic straws (200 per box)
- 1 ball twine (200′)
- 3 rolls ticker tape
- 1 60″ cloth tape measure
- 1 36″ measuring wheel (see page 26)
- 1 36″ calipers (see page 26)
- 1 plastic 8-oz measuring cup
- 1 plastic 16-oz measuring cup
- 1 set measuring spoons
- 2 1-qt square refrigerator containers
- 2 ½-pt square refrigerator containers
- 1 round plastic box with cover
- 2 plastic paint buckets
- 1 1-qt graduated plastic milk bottle with screw-on top
- 1 2-qt plastic food bottle with screw-on top
- 1 small funnel
- 1 large funnel
- 4 6″ x 1½″ semirigid plastic vials
- 8 18″ x 1″ semirigid plastic tubes
- 8 18″ x ⅝″ semirigid plastic tubes
- 8 18″ x ⅜″ semirigid plastic tubes
- 25 1″ caps
- 25 ⅝″ caps
- 25 ⅜″ caps

  } for tubes

- 1 $\frac{5}{16}$″ outside diameter thin-wall flexible plastic tubing, 20′ long
- 8 semirigid medicine cups, calibrated
- 2 100-ml plastic beakers
- 8 1-oz (30cc) plastic medicine cups
- 8 3-oz plastic cups with pouring spouts
- 8 5-oz cone cups
- 1 10-pin geoboard with pins 1½″ apart and ¾″ border
- 1 box multicolored rubber bands
- 3 36″ x 1¼″ x ¼″ sticks painted with greenboard paint
- 3 30″ x 1¼″ x ¼″ unpainted sticks
- 8 9-oz plastic cups
- 2 3-minute egg timers
- 4 student thermometers
- 1 storage box

To Collect

12″ rulers
popsicle sticks or coffee stirrers
paper clips
assorted package ribbons
1-oz plastic coffee scoops
milk cartons or bottles, juice containers, squeeze bottles, plastic refrigerator and food containers, poultry basters
assorted paper cups
plastic wading pool, infant's bathtub, or galvanized washtub
sand
floor covering — newspapers, polyethylene sheeting, old bed sheets

Setting the Stage

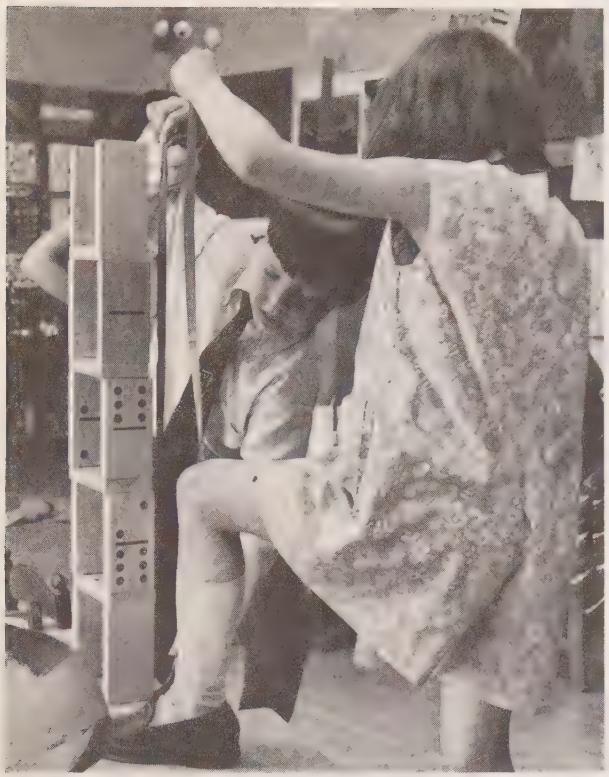
There are a number of things that you can do to encourage measuring activity. One of the simplest, but probably also the most important, is to provide a place in the classroom where measuring tools are conveniently set out. Some teachers put out all the materials to begin with, while others prefer to build up the supply gradually, introducing new materials as the need for them arises. Once set out, the measuring equipment should remain available for the rest of the year.

The *Class Kit for Match and Measure* is packaged in a box designed to hold measuring supplies within easy reach of children, even in crowded classrooms. Many other setups are possible.

However you choose to arrange the materials, you will want to be sure that children observe simple housekeeping rules. If they clean equipment and return it to its place after use, children will soon recognize that their freedom to make full use of the equipment is increased rather than restricted.

Once the measuring equipment is out, you will want to be alert for an opportunity to start children using it. In one first grade, a huge (6″ × 3″) pencil eraser on the teacher's desk provided a starting point. One child asked, "Where are the rulers? I want to measure our big eraser." This gave the teacher a perfect opportunity to call attention to other measuring equipment. After that, a frequent question was, "Can I measure?"

Simple Matching



Two children stand back to back to find out who is taller. One uses her palm to feel which head is higher.

Measuring is essentially a matching operation. Father matches a board that he wishes to cut against a ruler. Mother matches a roasting pan to the turkey, wrapping paper to a parcel, Margaret's last year's coat to her smaller sister. Periodically, Mark is matched against the family height record on the wall. Even young children become aware of this procedure and imitate it in their play.

The sorts of matching and comparing that children do and talk about as they build with blocks, play store, dress dolls, and sift sand are necessary preludes to understanding units of measure.

The simplest matching and measuring operations require no tools at all. Watching a few classmates compare their heights may give some children the idea of lining up the entire class, from the tallest person down to the shortest. A first grade teacher who fastened a tape measure against her wall in the fall reported that the children matched themselves against it without any apparent understanding of what the numbers stood for.

"What are you?"
"Forty-eight, I think."
"I'm bigger than you."
"Hey, Neil is fifty, too. Let me stand back to back with him and see if it's right."
"Jean's *not* the smallest. Miles is smaller . . . but Jean is still the smallest girl!"

A child begins to focus attention on both ends of the objects he is comparing after he has matched many things in many situations.

The young owner of a new pair of shoes holds one of them next to one of his old shoes and announces excitedly, "My new shoe is a lot longer than my old one!" Does he think to line up the two heels so that both shoes are in the same "starting position"?

In one class, a potato plant had grown very tall and was kept on a low shelf. Many children matched their height to the plant, saying, "The plant is higher. I'm smaller than the plant." Only three children realized that in order to measure themselves against the plant, they had to put it on the floor and then stand on blocks to make up for the height of the flowerpot.

A wide range of matching operations occur in children's play. The driver of a fleet of toy trucks suddenly decides to line up all his small trucks, his medium-sized trucks, and his large trucks in separate rows. He then proceeds to build a garage of blocks around each truck, ending up with small garages for his small trucks, and so on.

In the carpentry corner, a child discovers that the easiest way to make a lid to fit a box is to trace around the top of the box on the board from which he plans to cut the lid.

Just for fun —
Will the tallest person's shoe fit anybody else's foot? Do you think that the shortest person's sweater will fit you?

Measuring Length

The need to measure can arise for countless reasons. Once a child indicates that he is attempting to measure or compare the sizes of things, a helpful question or suggestion may open up new possibilities for him to think about and explore.

String, Ribbon, and Ticker Tape

It is not always possible or convenient to match and compare actual objects against each other. Tools are often needed to do the job. String, ribbon, and ticker tape are good tools for early measuring activities. All of them can be stretched across or wrapped around things and cut or torn off at the right length. Since they are not marked off, children can use them to measure without worrying about inches and feet. "Our classroom door is as wide as this piece of string." The piece of string becomes a "pattern" of the width of the door. "Patterns" of width, length, or height can be kept as permanent records. In one class, the children made a project of measuring heads with ticker tape. They wrote the owner's name on each tape and thumbtacked the tapes to the bulletin board.

Building Towers

Children often build tall towers of blocks just for the pleasure of watching them topple and crash.

Can you show me how tall your tower was before it toppled to the floor? Who can build the tallest tower?

If a child chooses to build his tower on a table, do the tower builders working on the floor agree when he claims that his tower is the tallest?

Sarah was sure that her tower was taller than Michael's even though his looked taller.

Ramps

If there are toy cars around the room, sooner or later some children will build different kinds of ramps for them to travel down. Here is a chance for them to compare speed, as well as distance.

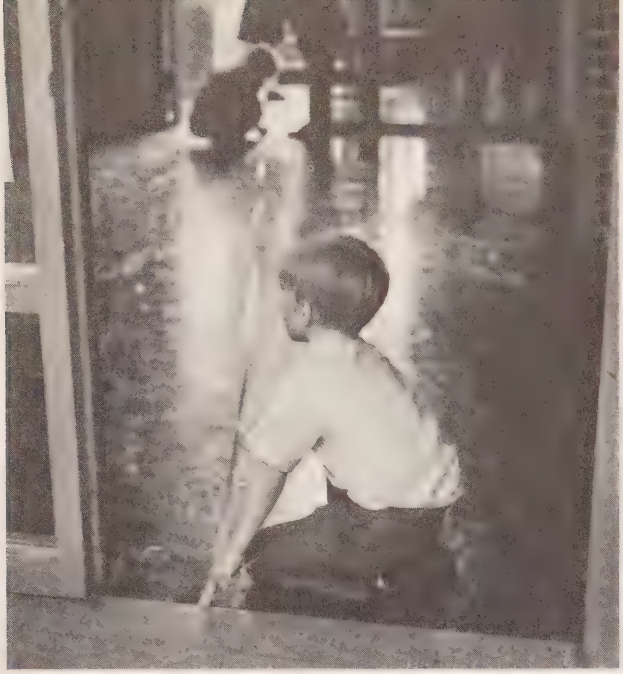
Does your car run as far off the end of a long, low ramp as off a short, high one? Can you think of a way to keep score for the cars on each ramp? Which ramp makes your car travel the fastest?

One six-year-old tried sliding down the playground slide in many different positions and asked his teacher to time him. In another school, where long ramps led down to the lunchroom, races and timing activities were very popular. The children marked off equal intervals along the ramps. Then they raced their turtles or rolled different objects past the marks and timed them by counting out loud. The teacher reported that they had become quite accurate at counting seconds, because they had played with a stopwatch previously, testing how long they could hold their breath and how long it took to run to the fence and back.

Playing House

Children often choose classmates according to size to be specific members of a family for the housekeeping corner. Fathers usually turn out to be taller than mothers, mothers taller than children, older sisters taller than younger brothers. As children match their heights to determine who will play which role, a discussion may arise about the heights of actual family members at home.

Can you bring in a record of how tall everyone in your family is?
Who is the tallest? . . . the shortest?
Where do you fit in?
Is the oldest person the tallest?
Can you make a record of some of your classmates' heights?



Measuring Long Distances

Long distances, measured in numbers, mean little to very young children. The physical act of measuring sometimes helps. Lisa measured the length of the school corridor with ticker tape. She made quite a sensation when she stood up with her arms full of tape and announced, "This is how far it is to the office."

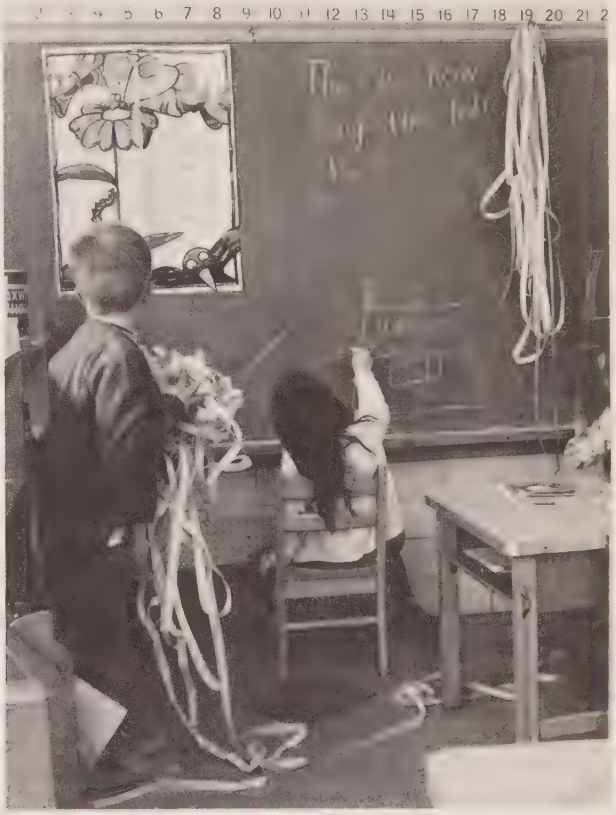
Next, she and her classmates decided to find the distance from their classroom to the playground. Some interesting questions came up.

"Should we fit the tape to each step?"

"Roll it straight."
"If it blows crooked, it won't be right, so we should fasten it down."

This time, it took two children to pick up all the tape. Even a quick glance at the two piles convinced most children that it was farther to the playground than it was down the corridor, but Lisa had to match one tape with the other, length for length. When she was satisfied, the children gathered up the tapes and hung them where everyone could see them.

Although these first graders were content with visual comparisons of the bunches of tape, older children liked to convert their "tape measurements" into feet or yards. Some found measuring wheels convenient for the purpose; others used yardsticks.



Growing Plants

Children who have planted seeds may be interested in measuring their plants as they develop.

How tall is your plant today?
Do you think it will be the same height tomorrow?
What about three days from now? Can you keep a record and find out?
Does corn grow faster than peas?
Is the tallest plant bigger all over?

Some children have kept track of a plant's growth by cutting strips of paper to match the plant's height each day. Placed alongside one another, these strips make a visual record.*

*See the Elementary Science Study unit GROWING SEEDS.

Shadow Play

Shadows are intriguing. They can shrink; they can grow; they can disappear altogether. After playing such games as tag and follow-the-leader with shadows, children may become interested in looking more closely at their own shadows and at shadows of things around them.

How can you tell whether your shadow is as big as you are?
Can you make your shadow grow bigger? . . . smaller? Can you make it disappear?
Compare your sun shadow with yourself in the morning and again in the afternoon. Did anything happen to the shadow?
Try doing the same thing with something that won't be moved — in the room or outside the building.

Some children thought of lying down on their shadows. No matter how they tried, this never seemed to work.

Melissa and Cory were surprised to find that the shadow was not on their paper when they came out after lunch.†

†See the Elementary Science Study unit LIGHT AND SHADOWS.

Keeping Animals

Animals in the classroom present possibilities for children to explore many kinds of measurement.

A group of youngsters had just about given up trying to measure their class guinea pig. A ruler was useless — the pig wiggled too much.

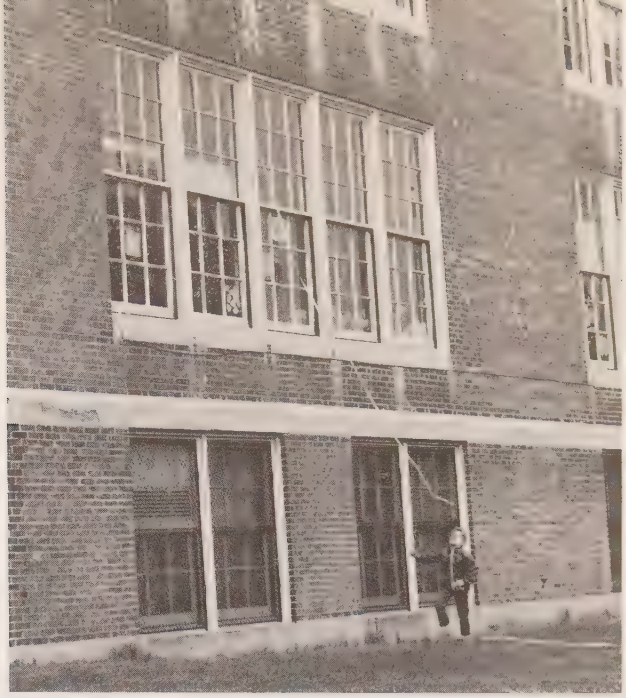
Aware of the children's frustration, the teacher made an effort to help them without telling them what to do; she simply stood near the group with a piece of string in her hand. It wasn't long before one child hit upon the idea of using the string to measure the guinea pig from nose to tail. After taking this measurement, someone asked for more string to find out how big the guinea pig was around the tummy. To everyone's amusement, the two measurements were nearly the same.

Children in a second grade were very impressed with the way a tiny gerbil could dig in the dirt. Taking careful measurements, they found that he was able to send the dirt flying behind him a distance greater than his own length (including his tail) and that the mound of dirt he piled up was much taller than he was. The children speculated about whether they could accomplish such a feat themselves.

Choosing a suitable cage for an animal may raise questions.

Is there room enough for the hamster to stand up? . . . lie down? . . . stretch out? . . . run around? . . . hide in a corner?*

*See the Elementary Science Study unit ANIMALS IN THE CLASSROOM.



Measuring the "Impossible"

After children have had some experience in measuring ordinary things, they may look for something really difficult and challenging to tackle. Two boys in a third grade wondered if they could measure the distance from their classroom window to the ground. They decided to use ticker tape.

The next question was about the classroom itself. How far was it from the ceiling to the floor? Reaching the ceiling posed a problem at first, but they soon solved it by attaching tape to a long pole and standing on a table. When the tape was stretched out on the floor, the children were surprised to see that it reached almost all the way across the classroom.

How would the first tape compare with the second one? As they unwound the tapes side by side, it became obvious that the distance from window to ground was much greater than the distance from ceiling to floor.

The teacher then asked the children if they could use the two measurements to figure out how many classrooms would fit between their window and the ground.

Some children guessed that three rooms would fit; others said four. A classmate interrupted the discussion with, "That's silly. You know Miss Smith's room is under us and Mr. Robbins' is in the basement. There are only those two rooms. Mr. Robbins' room is partly underground. But we measured from the windowsill in our room, so that makes it right."

Measuring Parts

Dealing with parts of a whole does not come easily to most children and should not be expected of them until they have had enough experience to understand "larger," "smaller," and "the same." An assortment of ribbons of different lengths in the dress-up corner helps introduce the notion of parts in simple ways.

Can you find a ribbon long enough to make a belt for your costume? Is the ribbon long enough to make two belts? . . . four headbands?

An episode which took place in a second grade classroom illustrates the need for this kind of experience. Two boys wanted to cut a piece of string in half. They both assumed it was a yard long; in fact, it was not quite a yard.

Taking the string to a yardstick, one boy carefully measured off 18 inches. His friend insisted that he knew a better way and, grabbing the string, folded it in half.

The first boy was not convinced. To prove his point he matched the folded string against the yardstick and announced triumphantly, "You see, it's only 17 inches, and it should be 18."

In an effort to help them understand the problem, the teacher gave them a much shorter string and asked the first boy if he could give his friend half of it. The boy was stumped. Finally, the teacher put the problem to him in a slightly different way.

"Suppose you had a piece of bread and you wanted to give me half of it. What would you do?"

"I'd fold it in two and rip it down the middle."

"Wouldn't that work with the string?"

The boy had to admit that it would, but he still insisted that "a ruler would be better."

Comparing body measurements offers another way of looking at parts in terms of the whole. Children find it amusing to compare the distance around their heads with the distance around their waists, the length of their feet with their height. Some of the relationships they discover surprise them.

If one of your friends is shorter than you, is his waist smaller than yours?
Is the person with the biggest waist bigger all over?
Compare arms, legs, heads.

In one kindergarten class in which children had done a lot of measuring, the teacher gave interested children a piece of ribbon as long as their outstretched arms. They used the ribbon to measure their heads, waists, ankles, and wrists, seeing how many times it went around. They noticed that the thinner the body part, the more times the ribbon went around. They found out that their head and waist measurements were often the same and that each child's ribbon went just about twice around his head or waist. This really surprised them. "How come? My head isn't as wide as my waist."

After much discussion, Charles came up with the explanation, "Your head sticks out in the back."

Billy added, "It isn't very long across your face from one ear to the other, but your head bumps out in back. That's what takes up so much of the ribbon."

In a second grade class, children cut string to match their height. The teacher suggested that they use these pieces of string to try to find things half as tall or twice as tall. Each string, which they called a "U," became a unit of measure. The children were soon measuring all sorts of things in terms of U's. When there was a fractional part of a U left over, they folded this piece over and over until they found out how many times it went into the U. They soon found out that since the U's were different lengths to begin with, people measuring the same object didn't get the same results in U's.

Working with parts is preliminary to working with standard units, such as inches, feet, and yards, which are simply parts of a particular whole. The more ways in which children learn to break down simple string-and-ribbon measurements into parts — and into parts of parts — the better prepared they will be to understand the function of standard units of measure.

As the need to interpret and communicate measurements arises, the usefulness of these conventional standard "parts" will become clear.

Just for fun —
Try recording all your body measurements one after another on a single piece of string, the way Chinese tailors are said to do. Tie a knot in the string at the end of each measurement.

Fingers, Hands, and Feet

Long before a child enters school, he puts his body to work measuring in a number of ways. One way to start children thinking about parts of the body as possible measuring units is to play a matching game.

Can you find something in the room that is as wide as your hand?. . . as long as your thumb . . . as tall as yourself?
Is your nose as long as your thumb?

Often a child may try the age-old method of measuring something between the index fingers of his two hands. The only drawback to this type of improvised ruler is that it tends to grow or shrink unpredictably. A child building a playhouse may discover that he has cut out an oversized door or an undersized doorway. Bungles of this sort teach children the value of taking measurements in a more dependable manner.

How many different ways can you use your body to measure?

Children have used hands, arms, and feet to figure out new arrangements for their desks and chairs, tables, and bookcases. One third grader attempted to measure the length of the school corridor with his head. He soon gave up this plan as impractical.

Two girls in another class went into the schoolyard and measured the shadow of the flagpole in "splits." One found that it was 4½ splits long; the

other found that it was 5. Soon the girls were joined by two boys who suggested that they all measure the shadow with their feet. At first the children tried covering the shadow with footprints they had cut out of newspaper. When they discovered that there were not enough footprints to reach the end of the shadow, they decided to walk the length of it instead. One of the girls counted 19 feet, the other counted 23. Both boys counted 17.

"My feet are smallest. I used 23," announced the girl with the most "foot counts."

One of the boys wanted to revise his count and make it less. "My sneakers are too tight, so my feet are really bigger."

The children made plans to measure the shadow of the pole throughout the next day to see how it changed. When they went out in the afternoon, they discovered that the shadow extended partway up the wall of the school building. This was a bit of a problem but they solved it to their own satisfaction.

"Stepping off" to measure a sizable distance strikes most youngsters as more logical than using a ruler. ("The ruler isn't long enough," is a comment frequently heard.) A child soon discovers, however, as did the children measuring the flagpole, that few people take the same number of footsteps while walking the same distance. He may be quick to notice and point out that "not everyone has the same size feet." Can he think of other reasons why foot counts vary?

Does it matter how you put your foot down when you are measuring with your feet?
Does everyone put his foot down the same way?

With experience, children come to understand the importance of using a measuring tool precisely — in this case, heel to toe, over and over again along the path to be measured.

Although parts of the body are not uniform instruments for measuring, they are useful for rough approximations, which children should be encouraged to make. A "stride," for example, is an accurate enough measure when you are taking photographs and must stand a certain distance away from your subject. In time, children learn to judge when an approximation will do and when greater accuracy is called for.

After children have done a good deal of matching and measuring with body units, they might like to try estimating the length, width, or height of things just by looking at them.

Pick out something in the room — the window pole, for example — and try to estimate its size in hands, feet, or your own height.
Now check your estimate.
How close did you come?

Making estimates helps children think about the most suitable units to use for measuring.

Just for fun —
Which body unit would you choose to measure —
. . . the height of a giraffe?
. . . the width of a hippopotamus's mouth?
. . . the length of a mouse from nose to tail?

Measuring with Sticks

While some children find ribbon and string satisfactory, others prefer measuring with hands and feet. Still others may seek out such devices as "sticks" (ranging anywhere from paper clips to yardsticks), tape measures, calipers, and measuring wheels. A variety of equipment in the classroom invites a range of ways of looking at the measuring process.

Children often express measurement in terms of the things they are playing with. David makes a train "8 blocks long." It takes "17 sticks" to fence in the barnyard Tom and Billy are building.

Can you tell how large your wrist is from the bracelet of paper clips you are wearing?

Youngsters in many classes found it interesting to make stick measurements of various distances within a school building — from their desks to the drinking fountain, from the sink to the aquarium tank, from their classroom to the cafeteria. In the first grade class in which children had matched their height against a tape measure on the wall, two boys knew they measured "49" but wanted to know how many "sticks" tall they were. They took the tape off the wall, put it on the floor, found 49, and placed a row of tongue depressors up to that mark. Then they counted the sticks.

Which "stick" do you think would be most handy for measuring the length of the room — a soda straw? . . . a paintbrush? . . . a yardstick?

In their first attempts to measure distance, children often construct an actual line of sticks from one point to another. If they run out of sticks before reaching their goal, someone may come up with the idea of reusing a few of the first sticks in the line. (Some think that this is not "fair.") Eventually, a child will think of using a single stick over and over again to finish the job. This new method should help children to see the advantages of using only one size of stick and the need for marking the position of the end point of a stick each time they move it.

Children frequently find that a distance they are measuring does not come out to an even number of blocks or sticks or paper clips. How do they go about interpreting the measurement when the answer falls between two numbers? Are they satisfied to ignore leftovers, or do they try to break off a piece of stick to fit the extra space?

Maureen was trying to find out how tall she was, using a roll of ticker tape. Stepping on the end of the tape with one foot, she proceeded to unwind the roll until the tape reached the top of her forehead. She then asked the teacher to cut the tape where her fingers were holding it.

MAUREEN (catching the piece of tape as it fell and matching it against herself): "It's too long. Oh, but that's because I was standing on it."

After tearing off the amount of tape she figured she had been standing on, Maureen walked around

the room with the remaining piece that matched her height. She held the tape first up to the door, then up to the chalkboard. Finally, she spied a yardstick.

MAUREEN (bringing the yardstick to the teacher): "What's this?"
TEACHER: "A yardstick."
MAUREEN (holding the stick up against herself): "Look, I'm a yard tall!"

Maureen then placed the tape of her height carefully on the yardstick. It was obvious, at once, that the tape was longer than the stick.

TEACHER (pointing to the portion of the tape extending beyond the yardstick): "But what about this?"
MAUREEN: "Oh, we can cut it off."
TEACHER: "Do you think we could use the yardstick to find out how long this little piece is?"
MAUREEN (looking at the yardstick and the leftover piece of tape): "Nope. The yardstick's too long."

Tiles and bricks on the wall or floor are particularly useful for approximating length. One third grader wished to compare his actual height with the height of his shadow. His friend helped him cut a piece of string to match his height and another piece to match the length of his shadow. Lacking a yardstick, the youngster compared the two pieces of string against bricks in the wall of the school building. "I'm 5 bricks taller than my shadow."

Calipers and Measuring Wheels

For some measurements, rulers and yardsticks are not appropriate. There are times when tools such as calipers and measuring wheels will do the job more easily.

Calipers can open up and be made to fit hard-to-measure places. Children in a second grade class had a great deal of fun measuring their classmates with the giant-sized wooden calipers in the *Class Kit.* After measuring everybody's height, they tried using the calipers for measurements they had been unable to take with rulers or tape. To their delight, they found that they could measure the width of a person's head, his neck, his ankle, and his toe.

A measuring wheel can run up walls, follow a wiggly trail, or go around the block.

Can you tell how far the wheel goes in one turn?

Many first graders in trial classes simply walked the wheel to-and-fro, counting aimlessly as they went. After racing the wheels from the principal's office to the classroom door, one child announced that the distance was 32 turns, while another child declared that it was 15 turns. A third member of the class objected. He had measured the distance and found that it was only 8. "I measured it with a yardstick, and the yardstick and the wheel are the same. I know they are because I rolled the wheel on the stick and the arrow on the wheel pointed down at the beginning and the end."

Once children catch on to measuring with turns, they enjoy using the measuring wheel over long distances.

Walk the wheel home. How far do you live from school?

Can you use the wheel to —

. . . lay out a baseball diamond?

. . . find out how far seeds travel from a tree?

. . . find out how far you can throw a football or hit a baseball?

How does your bicycle wheel compare with the measuring wheel? Do both wheels go the same distance in one turnaround?

Some children marked a spot on their bicycle wheel so that they could count the times the wheel turned. When they measured the wheel's turn against a yardstick, they discovered that they needed almost 2 yardsticks. They were surprised: "It doesn't *look* that much bigger."

Comparing Measuring Devices

The experience of relating one measuring tool to another helps children to be cautious about making such quick assumptions as, "I know the measuring wheel isn't a foot, so it must be a yard."

Terry insists that the bookcase in the corner is 3 feet long; Robin, that it is 1 yard long. How do they resolve their dispute? Do they think of comparing the yardstick and the foot rule side by side?

Similarly, when both yardsticks and metersticks are available, you can expect some child to make the discovery, "My yardstick is longer than yours!" Children in a trial class spent some time comparing the two "yardsticks."

> "You see, mine really is longer and it goes up to 39. Yours stops at 36."
> "And on this side of mine the numbers go higher. It says 100."
> "But the little spaces aren't the same."

In classes where Cuisenaire rods are in use, children have discovered that the white rod fits the numbered intervals on the meterstick and that ten orange rods measure the whole stick. One class named their meterstick the "white stick."

Once they have figured out some of the common relationships in measurement, children gradually develop more sophisticated concepts. A third grade class had experimented widely with measurement, using a variety of methods and equipment. They had measured themselves and their shadows and realized that the height of an object and the length of its

shadow were somehow related. They thought that they should be able to figure out the height of the school flagpole by measuring its shadow. As soon as the sun came out, some of them measured the shadow of the pole, while others measured the shadows of their buddies. Mark's shadow turned out to be 2 feet 2 inches long. "That's half as big as I am," declared Mark. "I'm 4 feet 4." Someone then voiced the idea that if Mark was twice as tall as his shadow, the flagpole should be twice as tall as *its* shadow. The shadow of the pole measured 19 feet. The children calculated from this that the pole must be 38 feet high.

At this point, Sarah, who had brought along the large wooden calipers, decided to check the measurement another way. She opened the calipers until they matched Mark's shadow. Turning the calipers end over end along the shadow of the pole, she found that Mark's shadow fitted into it nine times. The children had a feeling that they could use this information to determine the height of the pole, but they were not sure how to go about it.

To help them understand their calculations, the teacher drew a diagram of the flagpole and its shadow and of Mark and his shadow. After marking off the number of times Mark's shadow fitted into the shadow of the pole, the children concluded, "Then Mark himself will go into the flagpole nine times." This time, the figure established for the height of the pole was 39 feet.

The children were interested that the answers they arrived at by the two different methods were almost, but not quite, the same. A discussion developed about measurement and the accuracy of measurements.

"You could never measure exactly," insisted John. "Nothing is completely accurate, except two and one makes three, and things like that."

A short while later the boys went off to the principal to check the height of the flagpole. They were pretty certain that he would know how tall it was, "because," they explained, "you have to pay for flagpoles by the foot."

How High Do Balls Bounce?

A fourth grade class was working on the problem of how to handle variables. Sally and Sheila tried an experiment they had heard about on television. Their question was: How high do balls bounce? The problem seemed simple enough to begin with.

They collected eight different balls and set up a wall chart marked off in 6-inch intervals. Sheila dropped each ball in succession from the 6-foot mark, and Sally noted the height of the bounce and recorded it in her notebook. Sheila disagreed with Sally's observations until she realized that she couldn't "tell exactly" because she was looking down. The girls tried each ball several times and found that it bounced to about the same height each time "if you just dropped it without pushing it." Since they also found out that they couldn't record the bounce more accurately than within about 3 inches, they made a rough average of the heights to which each ball bounced and marked this on the wall chart. Next they decided to check the bounce when they dropped the balls from different heights. They systematically tried each ball from 5 feet, 4 feet, 3 feet, 2 feet, and 1 foot and recorded all their data in a notebook. They now had a notebook full of figures and an uneasy feeling that something funny was going on, but they were unable to think of any way to record their data to reveal what was happening. They thought that it would be "too confusing" to mark the height of all the bounces on the wall chart itself.

At this point, the teacher suggested that the children might be able to make a "picture" of their data with construction-paper strips. They could assign a color to each ball and cut strips of that color to represent the height of its bounces. It made sense to the children to cut the strips as many *inches* long as the feet the ball had bounced. As they measured and cut paper for each ball, using their recorded data, the children soon realized what had been bothering them. The ball that bounced the highest from 6 feet did not bounce the highest from 5 feet. Some balls bounced in such a crazy way that the children questioned their data. For example, ball H bounced its highest from 4 feet, lowest from 1 foot, and next to lowest from 6 feet. Unfortunately, ball H had "vanished" by this time, so the children could not repeat their experiment. They decided that they should try again with a new set of balls and hide the balls at the end of each day until they had finished the experiment.

Measuring Area

Paper and Cloth

Doll corner and playhouse activities and simple building at the workbench abound in opportunities for children to deal with two-dimensional measurement. Odds and ends of yard goods and cast-off materials provide them with opportunities to cover surfaces of different sizes and shapes — to make tablecloths for the playhouse table, a cover for the doll's bed, costumes for dressing up. Even wrapping a present for mother calls for matching the gift to the right amount of paper.

Patternmaking — for puppets, doll's dresses, costumes for dress-up, and the like — takes children a step further and challenges them to experiment with different ways and means of measuring surface area. Newspaper or large rolls of wrapping paper should be on hand for these purposes.

A class of first graders undertook to make paper patterns of themselves. The children stretched out full length on large sheets of wrapping paper. The patterns were cut out and matched against their models.

"It's taller because it's on tiptoe."

"Now we're both on flat feet."

After painting on faces and clothing, the children decided to arrange the patterns by height.

It wasn't always easy to tell who should follow whom.

Often live models had to be checked against each other.

Finally, the paper figures — "flat feet" and all — were lined up along the school hallway.

The lineup soon started some youngsters guessing about how many "paper children" it would take to reach the ceiling. One child said seven; another, nine. The teacher accepted the rather hazardous job of stacking the patterns, feet on head, up the wall. Everyone was surprised when it took only 3 "children" to reach the ceiling.

In their early efforts at making clothes, children rarely think of allowing for seams or the thickness of the body. Rather than warn them of this, it is better to let them find out about it for themselves. After they have tried on costumes that don't fit, they will find other techniques for making patterns, such as wrapping paper around themselves or the models they are working with.

Arranging a pattern on a piece of cloth is not easy. With practice, children develop an eye for laying out patterns so as to get the most out of a piece of material.

In one class, the children had a marvelous time drawing their outlines in all sorts of positions and mounting them as a mural.

Fresno State College, School of Education
Curriculum Materials

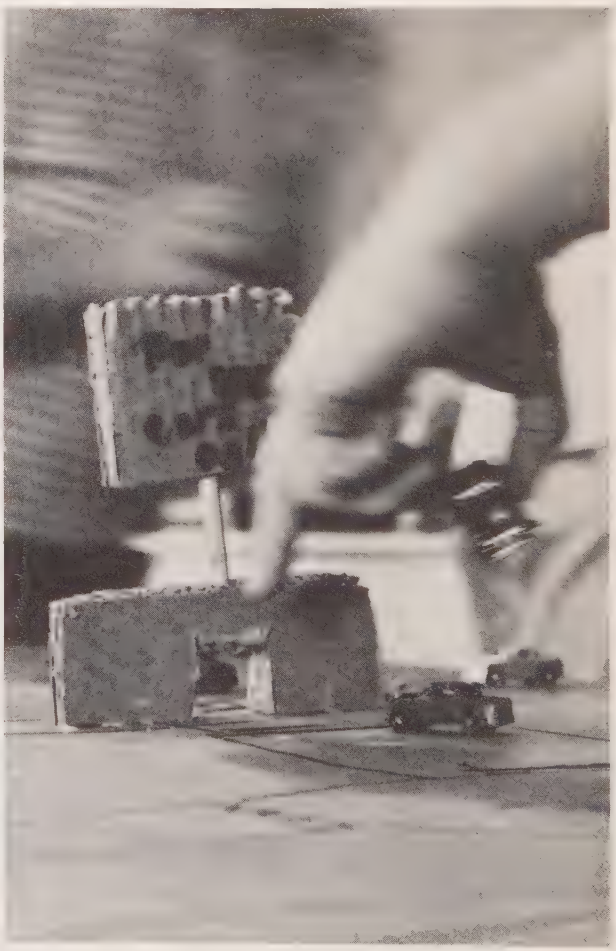
Models, Maps, and Murals

Models and maps, decorations and scenery, and creations of papier-mâché offer still more opportunities for children to work with areas.

Model houses, towers, and the like, made from assorted boxes and cans will be more attractive if they are covered with paper (even newspaper will do) before they are painted. As they do this, children will need to figure out ways to cover a variety of shapes — not only rectangles and squares, but cylinders, cones, and spheres as well.

A number of children in trial classes made puppets out of felt and papier-mâché. One boy thought of using a blown-up balloon as a mold for the head of his robot. A number of his classmates became interested in the problem of how to cover the balloon with paper. It took several tries before they discovered that strips worked better than whole sheets.

Some third graders decided to make a large relief map of their city. Separate groups of children worked on four different parts of it. When the sections were finally put together, the children found, to their surprise, that many of the streets did not meet as they should and that the scale of the buildings varied tremendously from section to section. One child who had constructed an underpass for vehicles found that buses and trucks got stuck in the tunnel she had made. She solved this problem by putting up a sign, "For cars only."



Sandbox landscapes provide an opportunity to deal with the three-dimensional shapes of mountains and gulleys.*

Planning a wall mural or designing scenery for a class play calls upon children's ingenuity and ability to work with large areas. Rolls of wide paper or old bed sheets make good backdrops. If these are not available, children can piece together sheets of construction paper.

What shall we use as a backdrop for our play?
Is an old bed sheet large enough?
How much can we fit into the scene we paint on it?
Is there room enough for two houses or just one?
How many sheets of construction paper do we need to cover the bulletin board?

Just for fun —
How many sheets of newspaper would you need to paper the floors or the walls of the whole school?
How many Sunday papers would you need to cover the entire city?

*See the Elementary Science Study unit MAPPING.

Geoboards, Pattern Blocks, Bricks and Tiles

Geoboards, Pattern Blocks, and comparable materials invite a child to explore area relationships.

Children like to fiddle with rubber bands on a geoboard, making mazes and shapes of all sorts.

Can you make two shapes which are the same size?
Can you cut your shape in half?
Try making a long low house on the board . . . a tall skinny house . . . a barn . . . a skyscraper.
Can you tell which one takes up more of the board?
Which house would you build in the city? Which in the country? Why?
Can you make a house or apartment like the one you live in?

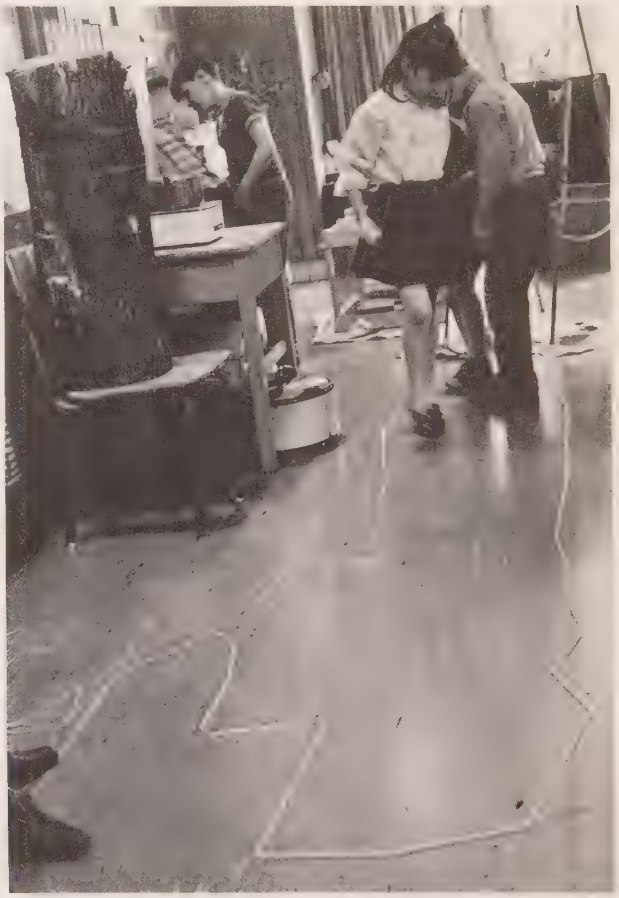
In one second grade, children's attempts to construct mazes resulted in a game. One player would devise an intricate network of paths on the board and then challenge another player to follow it to "Grandma's house." Players vied with each other to see who could create the longest and most complicated walk.

Pattern Blocks appeal to the eye and to the touch.* Some youngsters like to build with them. Others are more interested in making designs out of the various shapes. By arranging and rearranging the blocks into different patterns, children gradually become aware that several combinations of different block shapes can fill the same space. For instance, an area covered by four of the red trapezoids can also be covered by six of the blue diamonds or twelve of the green triangles.

*See the Elementary Science Study unit PATTERN BLOCKS.

Floor tiles and wall tiles or bricks are very useful units with which to measure area. Some children in trial classes enjoyed using soda straws threaded on a string as a sort of surveyor's chain to mark off areas on a tile floor. The children arranged their chain in a rough square and counted the tiles by stepping on each one in succession. They counted 74. Then they arranged the chain to cover a long narrow space and counted 34. They were surprised!

What shape will give you the largest number of squares?



"Making" a Boat

A class of third graders read about the *Mayflower* in a Thanksgiving Day story. They learned that the ship was 90 feet long and 25 feet wide and that there were 101 passengers and 48 crew members on board for the 65 days it took the ship to cross the ocean. The teacher, realizing that these facts and figures had little real meaning for the children, suggested that they all go out to the playground and measure off the 90-foot length and the 25-foot width. Next the class arranged themselves around their measurements in what they hoped was the correct shape. The "people outline" looked terribly small in the middle of the playground. How could 149 people have even fitted into it? To find out, they enlisted the help of other classes until they finally counted off 149 people "on board." What a crowd! It raised a lot of questions in the children's minds. Did people take turns sleeping? Where did they cook? What did the children do all day?

Measuring Volume

Cups, Containers, and Tubes

Sand or water play with cups, containers, and tubes is a pleasurable introduction to the idea of volume.* Indeed, the pouring, filling, and spilling that accompany such play are as important for school-age children as for preschoolers.

Activities with sand and water are best handled in small, informal groups. (When sand is not available, dry materials, such as sawdust, cornmeal, peas, or rice — almost anything that can be poured — may be substituted.) An area for sand or water play can be set up in a classroom with the following materials:

a large container —
  a plastic wading pool, an infant's bathtub, or a galvanized washtub

floor covering —
  newspapers and plastic sheeting for sand or water, or an old bed sheet for sand

a wide assortment of smaller containers in regular and odd shapes —
  school milk cartons; quart, half-gallon, and gallon milk cartons or bottles (whichever the children are accustomed to seeing); juice cans; plastic refrigerator containers; cups (assorted sizes and shapes of paper cups; standard measuring cups; coffee, tea, and medicine cups); squeeze bottles

*See the Elementary Science Study units SAND and DROPS, STREAMS, AND CONTAINERS.

in different shapes (some of the same capacity); poultry basters; plastic tubing; funnels; a set of measuring spoons

Before tackling the business of measuring volume specifically, children should be allowed plenty of freedom and time to "mess about" with the materials on their own. Preliminary play may last days or weeks, depending on the age and experience of the children.

Building sand castles, constructing waterways, and pouring sand and water over hands and through funnels teach the inexperienced participant as much about the nature and behavior of the materials he is handling as about spatial relations and magnitude.

Through sand play and water play, children deal with three-dimensional space and begin to establish basic notions about it. They may not wonder about precisely how much water and how many cups of sand they have for some time. Youngsters should not be forced to measure for the sake of measuring — a pointless pastime which can restrict thought and action to sterile exercises in counting.

Adding water to the moat necessitated some rebuilding but heightened the fun for these second graders.

Measuring should take place when and if interest in it arises. Castle builders may wish to find out how much water will fill a moat. Water-system operators may need to compare the capacity of tubes of different sizes. First encounters with measurement often occur quite by chance.

Teachers who have particularly difficult situations with hyperactive children have found that they can provide water-play activities, and they report that the benefits to the children make it well worth the effort to include these activities. In one first grade in which seven out of eighteen children were highly disruptive, water play was introduced as an activity for one or two children at a time, with a very limited amount of material to begin with and strictly enforced housekeeping rules. A child got a paint pail of water from the bathroom and was given a pan, a 3-ounce paper cup, a tube with two caps, another pail, and a sponge. He could fill the tube with the cup, holding the tube over the pan. If he spilled, he wiped the water up with the sponge, squeezing it into the empty pail provided for this purpose. This simple activity engaged these high-strung children for 45 minutes at a time. The teacher gradually added more materials as the children were able to handle them.

Children find their own ways to use the equipment. The "high bubbler" was first a way to get a drink and later a great way to fill bottles and jars.

A second grader was pouring water from a plastic tube into whatever cups and containers she found handy. Suddenly she made the discovery that her milk carton held the same amount of water as the tube. This amused her. Laughing, she told the teacher, "I drink a whole tube of milk twice a day."

Children are certain to be surprised when they compare the capacity of some of the cups, containers, and tubes. A short, fat jar may turn out to hold the same amount of water or sand as a tall, thin tube.

Getting water to flow from one container to another occupied these boys for half an hour. They found that they should have used a larger bottle to catch the water.

Children who have done linear measuring but who have had little experience with pouring and filling are likely to try using rulers to make comparisons of volume. One second grader selected a short, wide container and a short, slender vase. He filled both with water and then measured the height of each container with his foot rule. When the two containers turned out to be about the same height, the boy was confident that both held the same amount of water.

A classmate objected strongly to this method of measuring. Pointing to the top of the wide container, she commented that the boy had forgotten "all the part in here."

The boy then attempted to measure the diameters of the containers. His classmate still wasn't satisfied. "What about the part below? What about all this?" The girl picked up an empty jar and thrust her fist into it to show that she meant the entire inside, not just the top surface.

At this point the boy shrugged his shoulders and gave up. The girl struggled with the problem a while longer until she hit upon the idea of pouring water from one container to the other to see if they both held the same amount. Most children are able to accept and use this strategy for comparing volumes only after a great deal of pouring and filling experience.

It is difficult for youngsters to believe that the quantity of the contents remains the same even though the shape of the container changes. Some-

times the water or sand that fills one container does not fill another. Is the first container bigger because it is full, or is the second one bigger because more could be added to it? What if the water or sand overflows? Which container is larger then?

Children must work through these puzzling questions in their own way and in their own time before they can be expected to make comparisons and measurements with any degree of understanding.

Geo Blocks

A good way for children to acquire a feeling for the comparative volumes of different shapes and sizes is through play with blocks. Standard kindergarten blocks and Geo Blocks* are designed to stimulate such investigations. Fitting blocks of different sizes together to make increasingly intricate structures gives children firsthand experience with area and volume relationships. Children who have done a lot of building with Geo Blocks will know without counting how many small (1-inch) cubes it takes to construct a big (2-inch) cube.

*See the Elementary Science Study unit GEO BLOCKS.

Another Way of Measuring—the Equal-Arm Balance

An equal-arm balance† is an excellent piece of equipment to have available for reinforcing some of the ideas which children explore in their work with volume. If the balance is new to them, they will need to spend time getting used to it. Gradually, they begin to think in terms of one load being heavier or lighter than the other and become confident that loads which balance each other weigh the same amount. Now they can use the balance to compare weights, and someone may think of this method as another way to decide whether a quantity has changed when its shape changes.

Balance a lump of modeling clay in one pan by adding objects to the other pan until the balance is even. Now roll the modeling clay into a snake. Does it still balance?

What happens if you break the snake into little pieces? Can you put a lump of modeling clay in one pan that will balance the pieces of the snake in the other pan?

Balance a group of blocks against a different group. Do the blocks still balance if you build them into a house on the pan?

In comparing weights, children are approaching weighing in the same way they are approaching other kinds of measuring. Ideally, weighing activities should go on simultaneously with the activities suggested for linear, area, and volume work. Children progress from units of their own choosing to grams, ounces, and pounds, much as they move from the "popsicle stick" to the foot and the yard. Weighing thus becomes another way of measuring, and each activity reinforces the other.

†See the Elementary Science Study unit PRIMARY BALANCING.

Everyday Problems of How Much and How Many

Once children are comfortable with making comparisons of volumes, they can turn their thoughts to problems of how much and how many. The total amount of food that different living creatures eat is fascinating to consider.

How much food do your classroom animals or household pets eat every day?
Does the guinea pig eat a spoonful of pellets? . . . a handful? . . . a bagful?
What about a gerbil? . . . a bird? . . . a fish? . . . yourself? . . . everybody in the school?
Do all the plants in your classroom need the same amount of water every day?

Making comparisons of the amounts of food which they and their various pets consume is one way for children to work into standard units.

Can you compare how much you eat with how much your dog eats?
What did you use to make the comparisons — cups? . . . spoons? . . . bowls? . . . the number of meals? . . . the weight of each meal?

Just for fun —
A hummingbird sometimes eats twice its weight in food in a day. A shrew eats as much as a hundred times its own weight in food in one day. If you ate a hundred times your weight, how much food would you eat in a day?
How many times your present weight will you eat in twenty years?

Formulas and Recipes

Formulas given in parts also emphasize the need for children to arrive at their own standard units and use them consistently and to select units of a size appropriate for the activity. (If you want to end up with a pailful, you will not want to measure it out in tablespoons.) Almost any kind of container can serve as a standard, provided it is filled to the same level each time it is used. Play-Doh, bread dough, finger paint, and papier-mâché are a few concoctions which children can measure in this way. Older students might like to try the following formula for a chemical garden:

1 part household ammonia
3 parts water
3 parts table salt
3 parts bluing
Mix together and pour over rocks, sand, sponges, wood, or bits of brick and cement spread out on a metal tray. Let stand. Watch the crystals grow!

The preparation of fruit punch for the entire class calls for a lot of measuring. Children must consider not only the proportions of the ingredients but also the number of children to be served and the size of the drinking cups.

Determining the yield of the pitcher or jug in which the punch is made may turn out to be a harder job than it looks. When asked how many children could be served cups of punch from a gallon jug, a youngster in third grade held the

standard cup up against the jug and proceeded to mark off how many times the cup fitted into the height of the jug. "Three," was her answer.

"Only three children from the whole jug?" asked the teacher.

"Yes," replied the girl, holding the cup up to the jug again. "Three children."

After the child had poured out two cupfuls, making scarcely a dent in the contents of the jug, the teacher asked the girl what she thought now. The child clung to "three." It was not until the third cupful had been emptied out that she looked at the jug, which was still almost full, and said, "I guess it's more than three."

How much punch will you need to make to provide for refills at your party?
What if there's some punch left over? Can you pick out a container that is just about the right size to hold what's left?
Try finding a container of the right size for all sorts of leftovers: clay, crayons, marbles.

Following is a teacher's description of how her first graders made lemonade.

Before going on our picnic, we made pink lemonade. I bought six small cans of frozen lemonade for 12 cents each. I brought an unmarked 2-quart container to school for a pitcher, also a can opener, a wooden spoon, and cups. We read the side of the can and I wrote this on the board:

We need —
1 can of stuff
4 cans of water
to make 1 quart

I asked, "How much does our pitcher hold? It doesn't say, but I have one that says '1 quart.' Can we use it to find out what our pitcher holds?"
Heidi said, "Fill the quart and see how many times it will pour into the pitcher."
It went twice, so we decided that the pitcher held two quarts.
"How many little cans should we use if the pitcher holds two quarts?"
Jean said, "We need to use — two cans of lemonade and eight cans of water."
"I have six little cans of lemonade. How many times can we fill the pitcher?" (I drew this on the board.)
"Fill it three times!"
I told the children that each can of lemonade cost 12 cents and asked, "How much did it cost for each pitcher? How much in all?"

Cups, pints, quarts, and gallons become real to a child as he handles them. Distinguishing one quantity from another becomes important to him when there is reason for telling them apart.

Children in a second grade set about the task of changing the water in their aquarium. The teacher reminded them that tap water should be treated with conditioner before it is added to a fish tank. The directions on the back of the bottle of conditioning tablets called for one tablet for each gallon of water.

Although most of the children knew the word "gallon," none of them had any idea of the amount it stood for or of how to go about getting it. After rummaging through a variety of containers around the room, someone came up with a milk carton marked "one-half gallon." Putting their heads together, the children concluded that two half gallons would make one whole gallon. From there, they went on to find out how many gallons it took to fill the bucket in which they mixed the conditioner and how many buckets it took to fill the fish tank.

How many different ways can you find to make a gallon?

Most cooking recipes call for conventional standard measures. Simple recipes for puddings and cookies are fun and easy for youngsters to follow.

In one trial class, a group of students became interested in making bread. To produce a loaf of bread good enough to eat requires careful measurement of volume, temperature, and time. The making and baking of loaves that were eatable (and loaves that were *not*) taught the young bakers a lasting lesson about the usefulness of measurement.

More Measuring

The suggestions in this book are directed primarily toward the kinds of measuring that children can approach physically, either by making direct comparisons between things or by using a tool to determine size.

Time, temperature, weight, rate, value by price, and size by number (such as population of a city) are equally interesting for children to explore. Opportunities for one or more of these other kinds of measurement are sure to come up in almost any project. The cost of a flagpole and of lemonade, the speed of cars, or the rate at which a child goes down a playground slide are examples already mentioned.

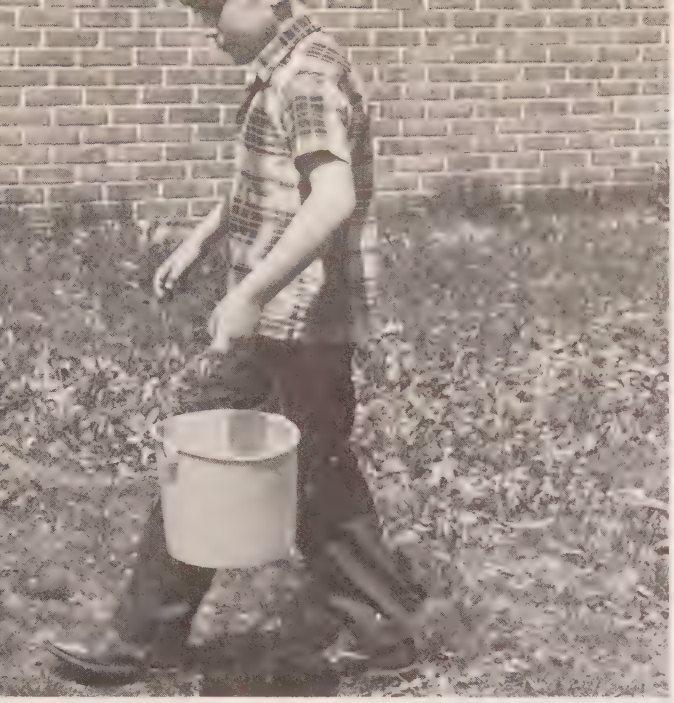
In trial classes, teachers found it useful to have timing devices, thermometers, and weighing devices (especially an equal-arm balance) as part of their measuring equipment.

A three-minute egg timer was very popular for establishing time intervals. Kitchen timers and alarm clocks were also used. Stopwatches were fun, although children often decided that counting was easier.

How high a tower can you build before the sand runs out?
How many turns does it take for you to finish your story?
How does the timer compare with a clock?
Do these two timers run out at the same time? (No!)
Is the "fast" one or the "slow" one the same as "clock three minutes"?

Making maple syrup was a project in which temperature, weight, and volume relationships all came up as part of the activity.*

*A pamphlet, *Maple Sirup [sic] Producer's Manual* is available for 60 cents from the Superintendent of Documents, United States Government Printing Office, Washington, D.C. 20402.



Lugging the sap to the classroom

. . . pouring it into storage containers

. . . and looking at all the containers together

. . . impressed the children with how much sap they had collected.

One boy decided to weigh all the containers, one by one, on a large postal scale and compare their total weight with the weight of the final product. It took a big kettle and a long time to boil the sap down. In fact, it took so long that the final boiling had to be put off until after April vacation. As the sap heated up, the children wanted to watch the temperature go up. They found that their thermometer went to the top before the sap started to boil.

"We need a better thermometer."
"Smells like syrup."
"How little we have left!"

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I Do and I Understand Describes how a number of British teachers have changed their classrooms in order to provide a setting that will give children a better opportunity to learn. To quote from the introduction, "To achieve understanding, young children cannot go straight to abstractions . . . they need to handle things. . . . But 'setting children free' does not mean starting a riot with a roomful of junk for ammunition."

Beginnings I Deals more specifically with examples of how equipment is used to generate learning. Children's work illustrates the book.

E | elementary
S | science
S | study

08-BXA-724

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07-017721-X